ARTICLE V

REPORT ON PHYLLOPOD CRUSTACEA (ANOSTRACA, NOTOSTRACA AND CONCHOSTRACA) INCLUDING A REVISION OF THE ANOSTRACA OF THE INDIAN EMPIRE

By Richard M. Bond

(Received February 19, 1934)

INTRODUCTION

The Phyllopoda of the Indian Empire have received sporadic attention since the time of Baird, who, in 1860, described *Streptocephalus dichotomus* from a single male specimen which was found swimming in a pail of milk. Since that time Sars, Gurney, Daday and some others have added to the knowledge of the Phyllopoda of the region. Professor G. E. Hutchinson has kindly turned over to me for examination the collections of these animals that he made as Biologist of the Yale North India Expedition.

The Notostraca and Conchostraca taken by the expedition are few in number, and it seems wise, in these groups, to limit this treatment to the forms in this collection. In the case of the Anostraca, however, the collections brought back are much more complete, and for this reason, and because of the ecological and zoogeographical importance of the group, it seems proper to treat them at greater length.

In this undertaking I was greatly aided by Dr. Hem Singh Pruthi, who secured for me the loan of all the unidentified Anostraca in the Indian Museum in Calcutta, in addition to sending me named specimens of certain forms. Records based on this material are marked with an asterisk (*) throughout the present paper. This loan material in addition to the Y. N. I. E. collections has given me an opportunity to compare a larger series of specimens of certain of the species than has probably been assembled hitherto. As a result, I have raised a "variety" to full specific rank, described 3 new subspecies, and am able to record for the first time the occurrence of a species in Kashmir hitherto found only in Mongolia and Manchuria.

In the descriptions of the larger groups, such as families and genera, I have frequently borrowed, almost verbatim, from the clear, concise paper on the South African Phyllopoda, by Barnard (1929), to whom I am much indebted.

Subclass BRANCHIOPODA

The classification used in this paper is not only perfectly defensible on purely morphological grounds, but has the added recommendation that it follows ecological as well as structural lines.

Body uniformly segmented, usually elongate, usually ending in a caudal furca; without carapace, with a dorsal shield-like carapace, or with a bivalve carapace. Compound eyes

present, and usually a persistent median eye. Five to 19 (in living forms) pairs of trunk limbs, which are simple foliaceous, modified foliaceous, or (rarely) pediform. Two pairs of antennae and 2 pairs of maxillae present, the 1st antennae and 2nd maxillae usually much reduced.

Order PHYLLOPODA (Euphyllopoda)

Branchiopoda with 10 or more pairs of trunk limbs all simple foliaceous, or with the anterior 1 or 2 pairs somewhat modified for clasping the ♀ or as tactile organs. Development (with the single exception of *Cyclestheria hislopi*) always with a metamorphosis from a free-swimming nauplius or metanauplius stage. The heart has several pairs of ostia.

Suborder I ANOSTRACA

Phyllopoda with an elongate body and without carapace. With 11 to 19 pairs of simple foliaceous trunk limbs. Paired pedunculate compound eyes, a median ocellus in front. First antennae small, 2nd antennae large and modified for clasping in ♂. Eight or 9 postpedigerous (abdominal) segments, the first 2 of which bear the external genital organs and may be partly fused. Caudal furca when present never segmented. Paired eversible penes in ♂; ovisac formed by united oviducts in ♀ in which ova are retained. Young hatch as nauplii or metanauplii. (In this group the rami of the caudal furca are usually known as cercopods.)

Key to the Families and Genera of Anostraca of the Indian Empire

1. 2nd antennae of ♂ biarticulate
   - A. Basal joints of 2nd antennae of ♂ nearly or entirely separate
     - i. Basal joint of 2nd antennae of ♂ with no processes, or with small and simple ones only ..... *Artemiidae*
       - a. Distal joint of 2nd antennae of ♂ greatly flattened ..... *Artemia*
       - b. Distal joint of 2nd antennae of ♂ not greatly flattened ..... *Branchinecta*
     - ii. Basal joints of 2nd antennae of ♂ bearing 1 or more conspicuous fleshy processes ..... *Chirocephalidae*
       - a. (only Indian genus) ..... *Pristicephalus*
   - B. Basal joints of 2nd antennae of ♂ firmly joined to each other and to the front of the head to form a clypeus ..... *Branchipodidae*
     - i. Front of head of ♂ bearing 2 long filiform processes which are connate at base ..... *Branchipus*
     - ii. Front of head of ♂ without filiform processes ..... *Branchipodopsis*
2. 2nd antennae of ♂ triarticulate, cheliform ..... *Streptocephalidae*
   - A. (only genus) ..... *Streptocephalus*

Family ARTEMIIDAE Grochowski

1896 *Artemiidae* Grochowski. Verh. zool. bot. Ges. Wien, 45:99

Eleven pedigerous, 8 or 9 postpedigerous segments. Head without frontal process. Second antennae of ♂ biarticulate, not fused at base, or only slightly so. Legs with a single epite (branchial lamina). Cercopods jointed to last abdominal segment, or fused to it or absent. Ovisac subglobular or cylindrical. Distribution world wide.

Genus *Artemia* Leach

1819 *Artemia* Leach. Dict. Sci. Nat., 14:543

Body slender, abdomen often longer than trunk and head combined. Eight postpedigerous segments, the last one longest. Basal joints of 2nd antennae of ♂ slightly fused; inner margin with a small round setulose knob. Distal joint of 2nd antennae of ♂ much flattened, apically acute. Intromittent part of penes without spines. Cercopods movable, fused to last body segment, or absent. Body form more or less variable according to the salinity of the environment.

Daday (1910) reduced the many "species" which had been described to two, one of which was from Peru, and was placed in the subgenus *Callaonella*. But the "species" described by Daday as *salina*, of wide distribution, has been shown to be heterogeneous by the work of Artom (1906, 1911a, 1911b, 1912, 1922, 1926, etc.), who found that there are at least two types, diploid and tetraploid, which he distinguishes at various times as "univalens" and "bivalens" (1911b) or as "micropirenica" and "macropirenica" (1922), and these may be further divided into sexual and parthenogenetic subraces. Hertwig (1931) and Gross (1932) believe that Artom's "diploid sexual" *Artemia* really are diploid, but that his "diploid parthenogenetic" are tetraploid, and that his "tetraploid parthenogenetic" are octoploid. Their belief is based on the fact that the chromosomes of the parthenogenetic races are much larger, each chromosome probably being bivalent. The most recent review of the situation is by Stella (1933), who agrees substantially with Artom.

Now, the taxonomic value of these races has never been properly established, since Artom did not give formal descriptions, but used his terms rather as conveniences. Daday's species *salina* will undoubtedly have to be divided eventually on cytological and grosser structural grounds, but however the division is made, the name *salina* will have to be reserved for the form originally described under that name. This form (of which I have a few specimens from the type locality) was found in the salt pans at Lymington, England, and has been shown to be diploid and sexual—the type called "univalens" and "micropirenica" by Artom. Fortunately, for the sake of simplicity, this is also the only form that has so far been found in the Indian region.

Artemia salina (Linnaeus)

1758 *Cancer salinus* Syst. Nat. (10th ed.) 1:634

Locality: Indian Tibet: Tso Kar. 200 + ♂♂♀♀. 5-IX-32.

Reported from: Nowhere else in the Indian region, but it has been taken in a great number of localities in central and western Asia, as well as in other parts of the world. The Tso Kar colony may have come from eggs dropped by a caravan carrying salt, though there seems to be no reason for its not being found naturally at several localities in the Indian region.

Types: Ubi?

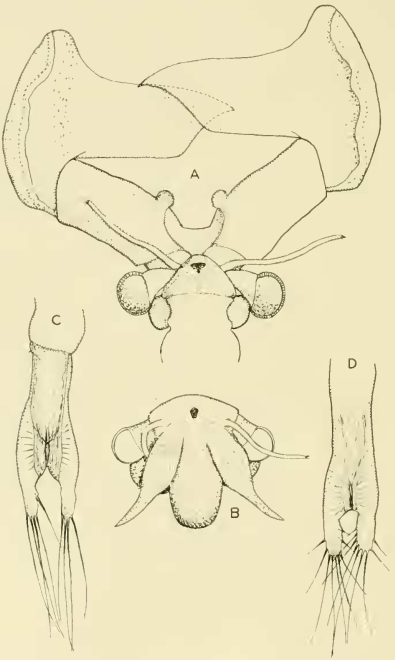

Figure 1.—*Artemia salina*. A, head of Tso Kar ♂ from above. B, head of Tso Kar ♀ from in front. C, end of abdomen of Tso Kar ♂ from above. D, end of abdomen of ♂ raised from Tso Kar eggs in 10% Na Cl solution. (Heads × 23, abdomens × 46.)

Always sexual, usually a more or less even distribution of the sexes (in this case about twice as many ♂♂ as ♀♀). Nuclei of the segmenting egg with 42 very small chromosomes. Nuclei of the ova before emission of polar bodies with 21 diads (observed in some of these specimens). Differences between specimens raised in brines of different densities not so marked as in the parthenogenetic *Artemia*; the caudal furca is never entirely absent, even in specimens from the strongest brines.

In the Tso Kar[1] specimens the abdomen is consistently about 20% longer than the trunk and head combined; the furca is somewhat reduced and bears from 3 to 10 setae on each ramus. The mature ♀♀ carry from 0 to 40 eggs (average 17.2). The ♂♂ average 9.96 mm., and the ♀♀ 11.02 mm. in length.

Professor Hutchinson brought back some viable eggs from Tso Kar which it has been possible to raise in the laboratory, though so far only in brines more dilute than that of the lake. As a consequence, the laboratory-raised specimens show better developed furcae and relatively shorter abdomens than those preserved in the field.

Genus *Branchinecta* Verrill

1869 *Branchinecta* Verrill. Am. Jour. Sci. (ser. 2) 48:250

Nine postpedigerous segments, the last usually shortest. Basal joints of 2nd antennae of ♂ perfectly separate; unarmed, or bearing 1 or more small processes of spines. Distal joint of 2nd antennae of ♂ usually simple, falciform; triangular, oval, or subcircular in cross section. Cercopods always jointed to last abdominal segment and freely movable. Ovisac of ♀ usually cylindrical, though very short in some species.

About 10 species are known from North and South America, Europe, and Asia. Only 1 species reported from the Indian region, though *B. paludosa* is found in Siberia to the north, and *B. ferox* is found east to Odessa and Jerusalem.

Branchinecta orientalis G. O. Sars

1901 *Branchinecta orientalis*. Sars. Ann. Mus. Zool. Acad. Imp. St. Pétersbourg. 6:144

Localities: Tibet: *Gyantse (coll. Maj. F. M. Bailey) 1 ♂, 2 ♀♀. 2-VII-23.

Indian Tibet: Chushol, Western Tibet, pond below village. Altitude 4336 meters. About 20 ♂♂ ♀♀. 10-VIII-32.

Lake near Chushol. Altitude 4491 meters. 1 ♂. 10-VIII-32.

Togarma Tso. Altitude 5217 meters. 7 ♂♂, 2 ♀♀. 10-VII-32.

Reported from: Hungary, Kecsemét; Russia, Charkov; 4 localities in the Pamir region (sec. Daday); Eastern Mongolia, Chuntu-nor (sec. Sars and Daday); Russian Mongolia (sec. Smirnov); Tibet, Gyantse (sec. Gurney).

Abdomen about the length of the head and trunk or a little longer, in both sexes. Mandibles with a sharp dentiform process on the posterior corner of the chewing sur-

[1] An analysis of Tso Kar water shows the following (figures are mg. per liter): Total solids 79266; SiO_2 25; Fe 1.8; Al 5.2; Ca 406; Mg 2716; Na 16346; K 5478; HCO_3 2141; SO_4 35075; Cl 11662.

face. The 2nd maxillae are provided with more setae than is usual in the order. Epite of the swimming legs of pairs 1-10 crenulate along the border; gill on legs of pairs 1-10 with margin entire. Last pair of appendages in both sexes with gill reduced in size and with a setose end; and with an epite the end of which is deeply notched. In ♂, the basal joint of the 2nd antennae is stout and cylindrical, with a slight setulose or smooth bulge on the medial face near the base. Distal joint of 2nd antennae smooth, unguiform, only slightly curved. The ♂ genital pouch has *2* posteriorly directed processes on each side. The dorso-

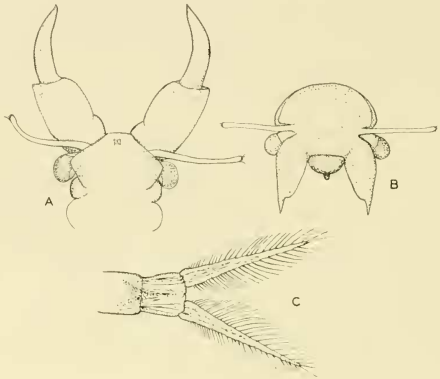

FIGURE 2.—*Branchinecta orientalis.* A, head of Chushol ♂ from above. B, head of Chushol ♀ from in front. C, end of abdomen of Chushol ♂ from above. (Heads × 11, abdomen × 15.)

lateral process hamiform with a ventrally directed side-process. The ventromedial process cylindrical. The cercopods of the ♂ slender, narrow, and pointed, straight, or slightly curved outward at the tips; both margins fringed with plumose setae nearly to the base. In ♀ 2nd antennae flat and blade-like with a well-marked acute terminal point, with a well-marked notch on the inner margin between the point and the body of the antenna. Ovisac does not reach beyond the 3rd post-genital (5th post-pedigerous) segment. Length: ♂ 12-38 mm.; ♀ 12-43.5 mm.

Daday (1910) divides this species into a small "*forma vernalis*" and a larger "*forma aestivalis*," but since all intermediate sizes are found and at all times of the breeding season, it seems unnecessary to make this distinction.

This species most closely resembles *B. ferox* (Milne-Edwards), and in fact both Daday (1910) and Smirnov (1932) are a little doubtful as to whether the two species are really distinct. It appears to me that they very probably are not the same, though they are certainly

closely related. *B. ferox* is proportionately much more slender, and averages considerably longer; the gill of the last pair of limbs appears not to be setiferous (from the descriptions—I have no specimens at hand); the cercopods of the ♂ are always outcurved, and their outer margins bear setae only near the tips; in the ♀ there is not a well-marked notch between the body of each 2nd antenna and its apical point; and the ovisac extends beyond the 3rd postgenital segment. Moreover, *B. ferox* has not been reported from central and eastern Asia, as it should have been if only environmental variations separate the two. *B. orientalis* has been reported from Russia and even Hungary, but both these records (especially the latter) I consider very doubtful. From analogies with the development of other anostracans, it appears very likely that adults of *B. orientalis* will resemble somewhat juvenile *B. ferox* even more closely than they resemble the adults of that species. From some of Daday's figures especially it seems possible that he has confused young specimens of *B. ferox* with *B. orientalis*.

Family Chirocephalidae Daday

1910 *Chirocephalidae* Daday, Ann. Sci. Nat. (ser. 9) 11:175

Eleven pedigerous, 9 postpedigerous segments. ♂ with biarticulate 2nd antennae, with separate basal joints. In ♂ basal joints of 2nd antennae bear 1 or more fleshy processes; or if not, the head bears a median frontal process; or there may be a frontal process as well as fleshy processes on the basal joints of the 2nd antennae. Legs with 1 or 2 epites. Cercopods movably articulated with last abdominal segment (except in *Thamnocephalus*). Ovisac usually more or less flask-shaped. Distribution world wide.

This is probably the least homogeneous of the families of Anostraca as defined by Daday. This author further subdivides it into 3 sub-families (which will not be treated here), but even with this division certan genera assigned to it by Daday will probably have to be removed to other families when they are more fully studied. The single Indian genus is close to *Chirocephalus*, and will certainly remain in the same family, whatever the taxonomic future of the group as now defined.

Genus *Pristicephalus* Daday

1910 *Pristicephalus* Daday, Ann. Sci. Nat. (ser. 9) 11:213

Abdomen without furca, usually shorter than trunk. Abdomen of ♂ unarmed, in ♀ bearing various sorts of spines, usually at posterior margins of the segments. Margins of cercopods setiferous, never spiniferous. Male without frontal process. Basal joint of 2nd antenna of ♂ often with a subspherical or cylindrical setuliferous process, and always with a pointed serriform process which is generally carried more or less coiled. Legs with 2 epites, except that last pair may have only 1, or the proximal epite of last leg may be much reduced.

Four species are known, occurring in parts of North Africa, Europe, Western and Central Asia. The species most closely resembling the one found in the Indian region is *P. josephinae*, which is found in Eastern Russia and in Siberia, and hence is the nearest geographically as well.

Pristicephalus priscus Daday

1910 *Pristicephalus priscus* Daday, Ann. Sci. Nat. (ser. 9) 11:224

Localities: PUNJAB: Sargodhar District, 3 miles South of Nuriwala. Altitude *circa* 305 meters. 4 ♂♂. 6-III-32.

SIMLA HILL STATES: *Between Theog and Matiana. Altitude *circa* 2300 meters. 5♂♂, 2♀♀. Coll. S. Kemp. X-21.

*Below Kupri. Altitude *circa* 2200 meters. 62♂♂♀♀ (all slightly juvenile). Coll. S. W. K. 28-IX-21.

Reported from: Naini Tal, Kumaon; Phagu, Simla Hill States; Suka Tal, above Naini Tal, Kumaon; Bhowali Bazar, Kumaon (sec. Daday).

Types: Daday designates no types for any of his species, but he had specimens of *P. priscus* from both the Paris Natural History Museum and the Indian Museum.

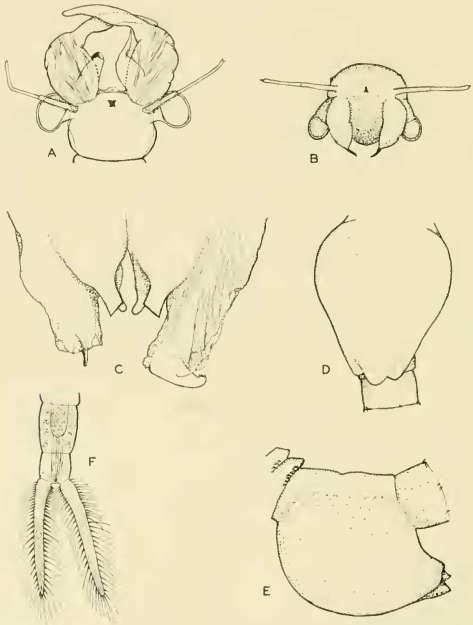

FIGURE 3.—*Pristicephalus priscus*. A, head of Sargodhar ♂ from above (× 15.6). B, head of Theog ♀ from in front (× 15.6). C, external genitalia of Sargodhar ♂ from below (× 33). D, egg sac of Theog ♀ from below. E, same from left side. F, end of abdomen of Sargodhar ♂ from above (× 42).

This characteristically Indian species has not been described nor figured except by Daday. The specimens that I have examined agree exactly on all important points with Daday's description and, moreover, the specimens (except those collected by Professor Hutchinson) are from the same region as Daday's, so that there can be no question of subspecific or varietal differences. None the less, there are a considerable number of small

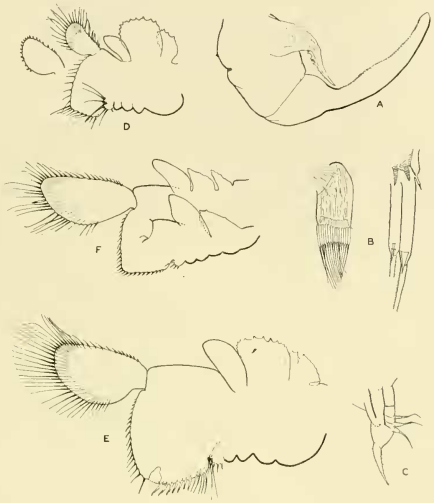

FIGURE 4.—*Pristicephalus priscus*. A, right 2nd antenna of Sargodhar ♂ from above (× 23). B, right 1st maxilla of Theog ♂ (× 38, enlargement × 85). C, right 2nd maxilla of Kupri ♂, finer setae not shown (× 64). D, E, F, 1st, 6th, and 11th legs of Sargodhar ♂. Offset from D, flabellum of same leg of Kupri ♂. Inset in F, gill and epite of same leg of Theog ♂ (all × 22).

points in which these specimens differ from Daday's description, and there are several characters which Daday seems entirely to have overlooked. His descriptions are in general unnecessarily detailed, and to correct all his observation it is needful for me to be very lengthy in my description also.

Male: Penultimate abdominal segment longer than any of the preceding 4. Last abdominal segment (which is about half as long as the penultimate segment) sometimes rather deeply notched between the cercopods. Cercopods long, narrow, ensiform; distal end more or less acutely pointed; fringed all round with moderately long plumose setae (Figure 3, f).

Head rounded in front. 1st antenna biarticulate, considerably longer than the basal joint of 2nd antennae (Figure 3, a). Basal joint of the 2nd antenna roughly $\frac{3}{4}$ as broad as long, roughly keg-shaped (Figure 4, a). A slightly raised area on the outer, distal margin of the basal joint of the 2nd antenna may be minutely setulose (not shown in figure); and there may be a short, ill-defined, transverse ridge, on the lateral side of this joint near the base, bearing 10-12 slender setae. Distal joint of second antenna with sub-conical basal portion, becoming flattened distally. Outer margin of distal portion is a flattened arc; inner margin sinusoid, and minutely serrate, with the points of the serrations directed basally. On dorsal interior surface of basal joint of the 2nd antenna is a pointed process called by Daday the "serriform process"; it is taeniform with the distal end drawn out; the margins are entire; a row of short digitiform papillae parallels each margin on the ventral surface. In preserved specimens, the serriform process is usually spirally twisted.

Chewing surface of mandibles in shape of a rough parallelogram, about 30-35 rows of teeth, the teeth being directed anteriorly; at dorsal edge of chewing surface are a few large, conical spines. I have been unable to detect any trace of the mandibular palp (which in several other phyllopod genera is represented by a small papilla). 1st maxilla broad and flat distally, ending in a row of 15-16 long, plumose, biarticulate setae. Basal portions of the setae armed with distally directed spines which number 1 or 2 on the lowermost seta and increase in number up to 8-12 on the uppermost seta. These spines are on the side of the setae opposed to the setae of the opposite 1st maxilla. Lower than the lowermost seta is a small spine which appears to be morphologically a much reduced seta, as it is supplied with its own tendon (Figure 4, b). 2nd maxilla reduced as is usual in the sub-order, ending in a large, slightly curved claw armed with a few minute spines; provided on its medio-anterior edge with three strong, biarticulate, plumose setae; on ventral surface, below bases of setae is a short, stout spine directed distally (posteriorly). Several patches of extremely fine hairs on the 2nd maxilla are much too fine to be shown in the figure (Figure 4, c).

Swimming legs 1-10 with 2 epites with markedly serrate edges. Last pair of legs variable in this respect, having 2 subequal, narrow, pointed epites, or with the proximal epite much the smaller, or entirely absent. Last legs of same individual may be unlike in this respect. Margin of the distal endite of legs 7 and 11 tends to be bluntly pointed; of legs 2-10 more evenly rounded. Gill with entire margin on all legs. Flabellum on legs 2-11 foliaform, with dorsal margin flatter than ventral. Flabellum of 1st leg foliaform, or subtriangular in outline. (Figure 4, d, e, f, setae and spines shown only for 2 distalmost endites.)

Each side of genital sac with 3 processes directed posteriorly. Ventral process ends in a lappet much flattened horizontally, end obliquely truncated, sometimes much more so than in figure. Inner dorsal process digitiform, sometimes slenderer than shown in figure. Outer dorsal process (penis) longer and much thicker than others, approximately cylindrical, ends in a flat, subtriangular plate which is eversible and retractable. The outline of the plate is roughly that of a boot viewed from the side. Following this analogy, the plate is attached by the leg, and bears 3 teeth on the top of the toe. These teeth are absent in juvenile individuals (Figure 3, c).

Total length variable, perhaps depending on season and food supply, averages about 18-19 mm. from forehead to end of cercopods.

Female: Second to 11th pedigerous segments with short transverse ridge across median dorsal line; viewed from the side, the highest point of ridge is towards posterior margin of

segments, especially posteriorly; at each end of each ridge are 1-10 curved spines along the posterior margin of the segment, the 2nd pedigerous segment having 1 spine on each side, and the number increasing posteriorly (Figure 3, e). According to Daday the 3rd to 7th abdominal segments have a girdle of spines around the posterior margin. In the specimens I have examined, these segments bear from about 6-25 spines on the posterior margin, increasing in numbers per segment posteriorly to a maximum on the 5th or 6th segment. The spines do not form a girdle, but tend to occur in groups of 2 or 3 with a space between the groups. The spines are absent, or small and few near the ventral mid line, thus giving an effect quite unlike Daday's figure (Figure 3, e). Cercopods as in the male.

Head smoothly rounded in front. First antenna biarticulate and longer than 2nd antenna. Second antenna oval in cross-section, tapering abruptly at distal end, to a pointed spine-like process (Figure 3, b). Eyes smaller than in male. Mouth parts as in male.

Legs as in the male.

Ovisac short and broad; ventral view something like a beef heart, but with an obtusely conical process on each side of the posterior end, and slightly dorsal to it (Figure 3, d, e).

Dimensions about the same as in the male or slightly smaller.

All of the specimens that I have examined are heavily infested with epiphytes and attached protozoa. This suggests that growth is very slow, with long periods between ecdyses.

Family Branchipodidae Daday

1910 *Branchipodidae* Daday, Ann. Sci. Nat. (ser. 9) 11:287

Eleven pedigerous, 8 or 9 postpedigerous segments. Front part of head of ♂ fused with basal joints of 2nd antenna to form a clypeus. Front of head of ♂ unarmed, or with a median process, or with paired processes. Second antenna of ♂ biarticulate. Legs with 1 epite. Cercopods freely movable, or fused to last body segment. Ovisac generally subglobular. The family is absent from North and South America.

Genus *Branchipus* Schaeffer-Daday

1766 *Branchipus* Schaeffer. Elementa Entomologica

1910 *Branchipus* Daday. Ann. Sci. Nat. (ser. 9) 11:311

Trunk segments smooth, unarmed. Postpedigerous segments unarmed in both sexes, or with short digitiform processes in ♂. Cercopods movably articulated with last body segment; straight and fringed all round with setae; or curved inward with outer margin setiferous, inner spiniferous. Distal joint of 2nd antenna of ♂ much longer than basal joint; falciform, curved inwards. Clypeus of ♂ with paired short blunt frontal processes. Paired, long filiform processes with bases connate arise from front of head (dorso-proximal part of clypeus). Second antenna of ♀ flat, blade-like, produced into a sharp apical point. Ovisac short, oval, with a prominent ventral lobe. In the present-day restricted sense, this genus contains only 2 species, one of which has been found only once, in the French Alps.

Branchipus stagnalis (Linnaeus)

1752 *Apus pisciformis* Schaeffer. Abhandl. v. Insecten. vol. 2.

1758 *Cancer stagnalis* Linnaeus. Syst. Nat. (10th ed.), p. 634.

1766 *Branchipus pisciformis* Schaeffer. Elementa Entomologica.

1906 *Branchipus pisciformis* Gurney. J. and Proc. As. Soc. Bengal (n.s.) 2:275.

1910 *Branchipus stagnalis* Daday. Ann. Sci. Nat. (ser. 9) 11:312.

Localities: No specimens of this species have come into my hands. It has been reported only once from India, by Gurney (1907), who examined specimens in the Indian Museum labeled "J. A. W. Murray, Sind."

Reported from: The greater part of Europe; North Africa; Palestine. The collections nearest India were made at Sudak in the Crimea, and Bingol Dagh in Armenia. (Cf. Daday (1910).)

Types: Ubi?

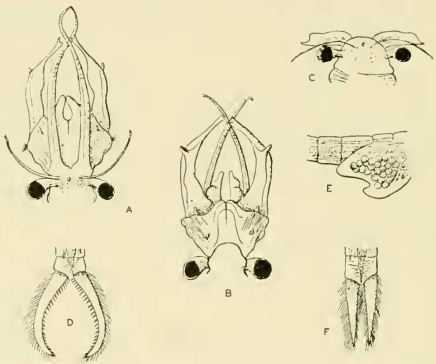

FIGURE 5.—*Branchipus stagnalis*. A, head of ♂ from above. B, head of ♂ from below. C, head of ♀ from above. D, end of abdomen of ♂. E, egg sac of ♀ from right side. F, end of abdomen of ♀. (All from Daday (1910); magnification unknown.)

Since I have seen no specimens of this species, I borrow the description (much shortened) from Daday, as well as some of his figures.

Male: Size very variable according to locality. Abdominal segments unarmed. Cercopods falciform, curved inward, outer margin setiferous, inner margin bearing slender spines. Clypeus with a short conical process on each side dorsally; with paired conical frontal processes; with a conical tubercle on each side, and a distal digitiform process on each side

ventrally. Distal points of the 2nd antenna with bituberculate tips, and with a digitiform process projecting anterolaterally from the ventrolateral margin at a point slightly distal to the middle of the joint. Front of head at dorso-posterior margin of clypeus with a pair of long filiform processes with connate bases. Total length, 8-20 mm.

Female: Cercopods straight, both margins setiferous. Front of head unarmed, gently rounded. Ovisac short, oval, acutely rounded posteriorly. Total length, 8.5-23 mm.

Genus *Branchipodopsis* G. O. Sars

1898 *Branchipodopsis* Sars. Arch. Mat. og Naturvid. Krist. 20 (4): 26.

Nine postpedigerous segments, the last shortest. Cercopods falciform, incurved, movably jointed to last abdominal segment. No median process from the vertex of head of ♂, but there may be a small median, ventral process. Basal joint of 2nd antenna of ♂ (each half of clypeus) with a conical, subconical or digitiform process on inner anterior side, and a small setiferous lamelliform process near the distal end. Distal joint strongly curved inward, often contorted, unarmed. A number of species are found in Africa, one in Asia.

Branchipodopsis affinis G. O. Sars

1901 *Branchipodopsis affinis* Sars. Ann. Mus. Zool. Acad. Imp. St. Pétersbourg. 6: 149

Locality: KASHMIR: *Nagmargh. 20-30 ♂ ♂ ♀ ♀. Col. F. Smith. VI-13.

Reported from: Mongolia, Mont Chingan (sec. Sars); Manchuria, near Tyn Chur. (sec. Daday); Russian Mongolia, near Lake Baical (sec. Smirnov).

Types: Museum of Natural History, Leningrad.

These specimens were received in an extraordinarily damaged condition, apparently having been completely dried at some time in the past. They were very brittle as received in alcohol, and not a single specimen had escaped breakage. It was at first impossible even to make sure of the genus, but by treating with 5% KOH solution, the horn-like interior was softened, and the integument resumed something of its former shape. They were then lightly stained with tetrabromfluorescic acid, and preserved in glycerine to protect the now very soft specimens. Since these specimens are in such poor condition, the description and figures are taken largely from Sars (1901).

Body somewhat more slender than usual in the genus. The paired median processes on the dorsal surface of the ♂ clypeus terminate in 2 rounded lobes, having between them a small spine; digitiform processes on dorsal, distal parts of the clypeus well marked. A small ventro-median, spinuliferous process on the clypeus. Distal joints of 2nd antenna of ♂ strongly curved, and somewhat expanded near tips. Second antennae of ♀ terminate in an acute pointed process. The 6th legs of ♂ have 5 rounded, tuberculiform processes between

* Indian Museum specimens.

the spines of the distal endite. (The Kashmir specimens appear to have only 2 such tubercles.) According to Daday (not mentioned by Sars) there are 2 spines on the under side of the last postpedigerous segment. These cannot be made out on the Kashmir specimens, though quite possibly because of their poor preservation. Cercopods of ♀ straight, pointed and setiferous; those of ♂ longer, strongly curved inward, and setiferous on the greater part of the outer margin. On the inner margin they are provided with spines which continue to, and a little around, the tips.

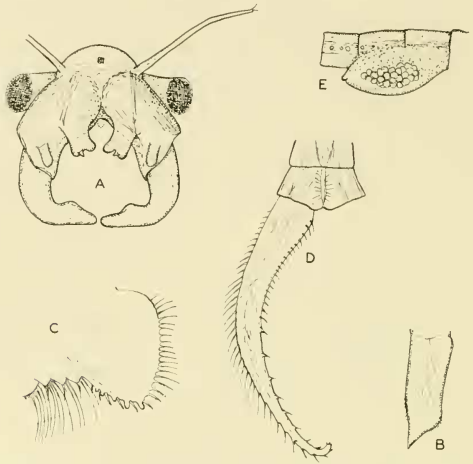

FIGURE 6.—*Branchipodopsis affinis*. A, head of ♂ from in front (×14). B, 2nd antenna of ♀ (×39). C, outer endites of 6th leg of ♂ (×32). D, end of abdomen of ♂. E, egg sac of ♀ from right side (×10.5). (All redrawn from Sars (1901).)

Family STREPTOCEPHALIDAE Daday

1910 *Streptocephalidae* Daday. Ann. Sci. Nat. (ser. 9.) 11:335

Eleven pedigerous, 9 postpedigerous segments, the last always shortest. Head in ♂ simply rounded in front, or with a frontal process. Second antenna of ♂ triarticulate, with distal joint cheliform, a curved, chitenous process projects more or less ventrally from the juncture of the basal and middle joints. Legs with 1 epite. Cercopods movably articulated with the last abdominal segment (except in *S. scalii?*). Ovisac cylindrical, usually elongate. Only 1 genus, which is found in all continents except South America.

Genus *Streptocephalus* Baird

1852 *Streptocephalus* Baird. Proc. Zool. Soc. London 20:20

With the characters of the family.

The species of the genus *Streptocephalus* hitherto described from the Indian region have been named *S. dichotomus* Baird, and *S. dichotomus* var. *simplex* Gurney. But an examination of the specimens of the Yale North India Expedition and the numerous specimens sent me from the Indian Museum has shown that such a classification is untenable. If it were to be allowed, a number of subvarieties of var. *simplex* would have to be erected, some of which would be geographically distinct; and even though the ranges overlap slightly, there already appears to be a geographical distinction between *S. dichotomus,* and *S. d.* var. *simplex*, so that a sub-specific distinction would be proper at the very least. If var. *simplex*, the more primitive form, had been described first, it would perhaps be possible to express the relationships without too much confusion, but under the present conditions it seems much better to raise Gurney's variety to the rank of a full species, with 3 sub-species. This (to some perhaps drastic) step has sound precedent in the suborder, and even within the genus, since *S. dregei* G. O. Sars, and *S. cirratus* Daday are equally close to each other. I may add that no intermediate forms have ever been recorded between *dichotomus* and *simplex*.

Streptocephalus simplex **simplex** nov. comb.

1907 *Streptocephalus dichotomus* var. *simplex* Gurney. J. and Proc. Asiatic Soc. Bengal (New Series) 2:276

Localities: Patiala States *Base of Simla Hills 1 ♂, collector for the Indian Museum. Date?

United Provinces: *Mirihan, Mirzapur, R. B. S. Sewell, coll. 30-XII-12.

Reported from: Cutch (Gurney); Calcutta (Daday).

Types: Indian Museum, Calcutta.

The distal chelate joint of the 2nd antenna of the ♂ is often spoken of as the "hand," the dorsal branch being the "thumb" and the ventral branch the "finger." For the sake of simplicity this terminology will be adopted here. The left hand of the ♂ from Patiala State is shown in Figure 7, with the parts to be mentioned in the descriptions labeled. The terms "dorsal," "ventral," etc., when applied to the 2nd antennae of the ♂ shall be applied as if these appendages were extended out directly forward of the head.

Body rather robust for the genus. Abdomen without furca scarcely longer than the trunk. Head of ♀ evenly rounded, with the 2nd antennae much folded and crumpled, often largely obstructing forward vision. Head of ♂ produced in front into a short conical protuberance which is plainly visible from above, lying between the bases of the 2nd antennae (as in Figure 8, d, d'). Pedigerous and postpedigerous segments simple and unarmed. Male genital sac of the form usual in the genus, with the usual cylindrical, spinous penes. Ovisac of ♀ a slender tapering cylinder, not reaching as far as the last abdominal segment, tip not bent. Cercopods in both sexes narrow and lanceolate, fringed all round with subequal

plumose setae. Cercopods very slightly longer proportionately in ♂ than in ♀. First antennae of both sexes not showing segmentation or pseudosegmentation. Second antennae of ♂ triarticulate. Basal joints cylindrical, superficially somewhat creased, usually bent more or less downward. At the juncture of the basal and middle joints is a ventro-laterally directed, slightly curved smooth process which is heavily chitinized. Middle joint of 2nd antennae of

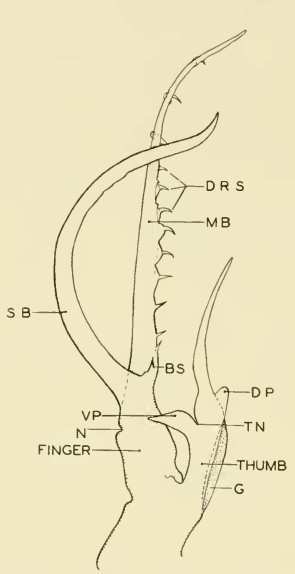

FIGURE 7.—*Streptocephalus simplex simplex.* Left hand of ♂ from Patiala State (× 13). N = finger notch; SB = sickle-shaped branch of finger; BS = basal spine; MB = main branch of finger; G = dorsal groove of thumb; TN = thumb notch; VP = ventral process of thumb; DP = dorsal process of thumb.

♂ with a sigmoid flexure; close to its basal end on the dorsal surface are 3 slender fleshy processes, the innermost one always larger, the other two may nearly equal it, or may be considerably smaller. All 3 are similar in shape, tapering, curved downwards, pointed, and with the lower surface provided with a row of small papillae. On the dorsal surface of this same middle joint is a row of about 10 slender processes, the middle ones usually being shorter. The whole of the middle segment of the 2nd antennae of the male gives the appearance of being superficially annulated. The hand, as seen from the outer side, is well shown in Figure 7. It will be observed that: the distance from the thumb notch to the tip of the

thumb is about half the length of the main branch of the finger as measured from the basal spine to its tip. The dorsal process of the thumb is prominent. The dorsal row of spines tends to run over onto the inner side of the main branch of the finger distally, and the sickle-shaped branch of the finger is practically smooth along its concave edge. The legs of both sexes have the epite serrate along the margin, and the gill of the last pair flattened, enlarged, and finely serrate along the end. Length usually about 20 mm. or more.

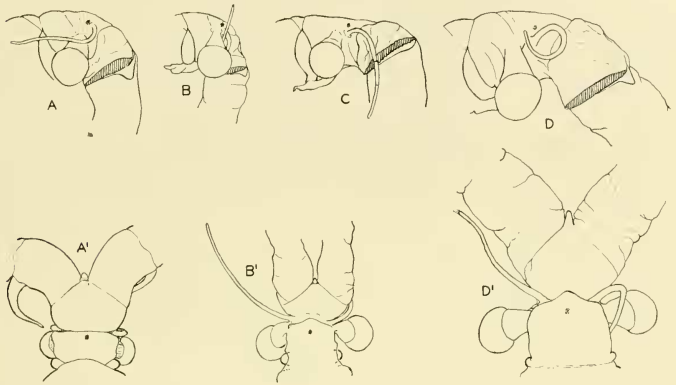

FIGURE 8.—*Streptocephalus.* A, *S. simplex echinus*, head from right side. A', same, from above. B, *S. s. longimanus*, head from right side. B', same from above. C, *S. s. arabicus*, head from right side. D, *S. dichotomus*, head from right side. D' same, from above. (All × 8.1.) Side views of heads show right 2nd antenna cut away to expose the frontal process; the cut surfaces are lined. Many of the differences other than the frontal processes are the result of the condition of the material. The frontal process of *S. s. simplex* appears to be exactly like that of *S. dichotomus*.

Streptocephalus simplex longimanus n. subsp.

Locality: MADRAS PRESIDENCY: Mahabalipuram. 2♂, 3♀, coll. Hutchinson. 4-XI-32.

Types: Peabody Museum of Yale University. Paratypes to Professor Hutchinson.

This subspecies differs sufficiently from *S. s. simplex* to make it seem worth while to make the distinction. The terminal joint of the 2nd antennae of the ♂ has a much shallower and less marked notch on the ventral side of the basal part of the finger. The sickle-shaped branch of the finger has no basal spine. The main branch of the finger has the spines on the dorsal edge very few (7-10), short and blunt. The thumb has no dorsal process, though the dorsal groove is present, and the length of the thumb measured from the notch on the distal side of the ventral process is actually greater than the length of the main branch of the finger measured from the dichotomy. The 1st antennae of both sexes are long and

exhibit a jointed appearance. The cercopods of both sexes are unusually wide at the base, and are much flattened dorso-ventrally. In other respects the two sexes appear to be essentially like the typical form.

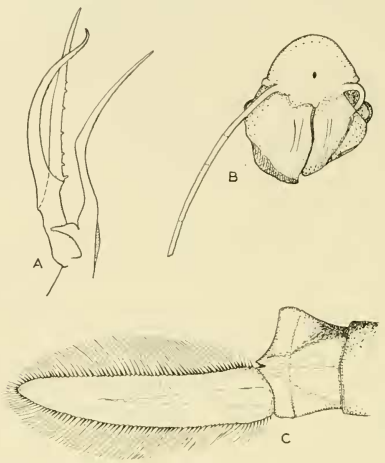

FIGURE 9.—*Streptocephalus simplex longimanus.* A, left hand of ♂ from outside (× 13). B, head of ♀ from in front (× 11). C, end of abdomen of ♂ from above (× 17.4).

Streptocephalus simplex **arabicus** n. subsp.

Locality: SOUTH ARABIA: Aden. 5 ♂, 5 ♀, coll. G. E. Hutchinson. 21-II-32.
Aden, 100 or more. Coll. G. E. Hutchinson. 7-XII-32.
*Aden?, 2 ♂ ♂, 2 ♀ ♀, coll.? Date?, poor condition and of doubtful provenance, quite possibly *S. s. arabicus*.

Types: : Peabody Museum of Yale University. Paratypes in Indian Museum.

Much like the typical variety, but for the following: First antennae of both sexes often appearing to be divided into 2 or more segments. Second antenna of ♂ with basal joints so much fused dorsally as almost, or completely to hide the short and ill-developed frontal process of the head when viewed from above; with the outer 2 fleshy processes of the 2nd joint much reduced in size (one may be missing), and with the dorsal row of spines on the main branch of the finger not tending to run over onto the inner face of the main branch distally. The finger-notch is well marked, and the proximal edge of it is

more or less produced. The 2nd antennae of the ♀ not very rarely bent or folded, and narrower than in *S. s. simplex*; sometimes produced into an obtuse point at the inner side of the end. The gill of the last legs of both sexes is perhaps a little narrower than in the typical form. The specimens collected by Professor Hutchinson on the different dates differ greatly

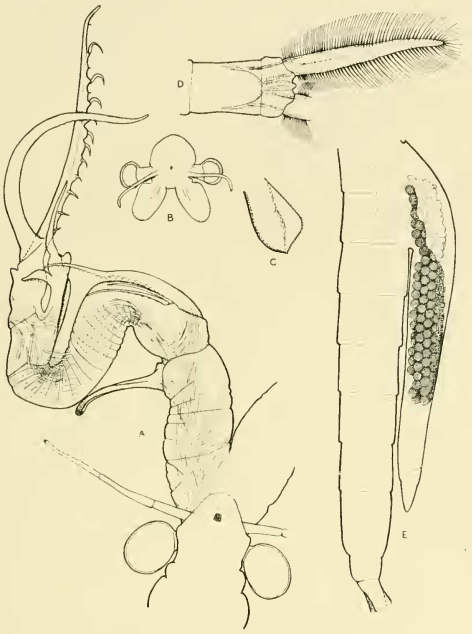

FIGURE 10.—*Streptocephalus simplex arabicus*. A, head of Feb. ♂ from above (× 12). B, head of Dec. ♀ from in front (× 7.4). C, left 2nd antenna of Feb. ♀ (× 12). D, end of abdomen of Feb. ♂ from above. E, abdomen and egg sac of Feb. ♀ from right side (× 12).

in size, those of February measuring about 23 mm. for the ♂ ♂ and 20 mm. for the ♀ ♀. The specimens taken in December, however, are the smallest sexually mature specimens I have ever seen reported for the genus, measuring only about 9 mm. for the largest ♂ ♂, and as little as 6 mm. for ♀ ♀ carrying eggs. In other respects they are precisely like the larger specimens.

Streptocephalus simplex **echinus** n. subsp.

Locality: Madras Presidency: *Godaveri (Town). 3 ♂, 9 ♀, coll. N. Annandale. 28-VIII-18.

Types: Returned to Indian Museum. One ♂ and one ♀, paratypes, retained.

Body and cercopods of both sexes relatively slender. First antennae of both sexes are relatively longer, and appear irregularly segmented. The 2nd antennae of the ♂ entirely without fleshy processes of the middle joint; the slender processes on the dorsal side of the distal part of this joint are reduced in number to 6-8; in the distal joint, the dorsal

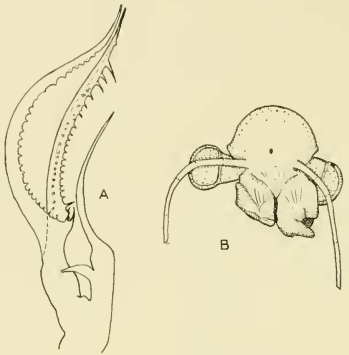

Figure 11.—*Streptocephalus simplex echinus*. A, left hand of ♂ from outer side (× 13). B, head of ♀ from in front (× 11).

row of spines of the main branch of the finger is more regular than in *S. s. simplex* and does not run over onto the inner side of the branch, and the spines are much more numerous. There is also a row of short, conical spines along the outer side of the main branch of the finger. The sickle-shaped branch of the finger is armed along the proximal 4/5 of its concave edge with short close-set spines which become somewhat papilliform distally. The thumb is a little longer than in *S. s. simplex*, its length from thumb-notch to tip being about 4/5 of the length of the main branch of the finger as measured from the dorsal spine. The dorsal process of the thumb is lacking, and the dorsal groove of the thumb is scarcely indicated. The finger-notch is obsolescent. The 2nd antennae of the ♀ ♀ are rather narrower than in the typical form. Length of ♂ ♂ about 20 mm., of ♀ ♀ about 18. In other respects this subspecies is very similar to *S. s. simplex*.

Streptocephalus dichotomus Baird

1860 *Streptocephalus dichotomus* Baird. Proc. Zool. Soc. London. 28:445

1900 *Streptocephalus dichotomus* Sars. Arch. Mat. Naturvid. 22(9):4

Localities: Madras Presidency: *Madras, Spur Tank. 10 ♂, 9 ♀, N. Annandale. III-11. *Tanjore (S. India). 1 ♂, 1 ♀, N. Annandale. 27-X-11.

United Provinces: *Baraunda Tank, Mirzapur. 11 ♂, 5 ♀ (juvenile), Mrs. N. M. Johnstone. 15-VIII-13.

Mysore: *Bangalore (India). 1 ♂, 1 ♀, N. Annandale. 13-X-10.

Reported from: India (Baird); Calcutta (Alcock); Shevaroy (Stevaroy) Hills (Sars).

Type: Ubi?

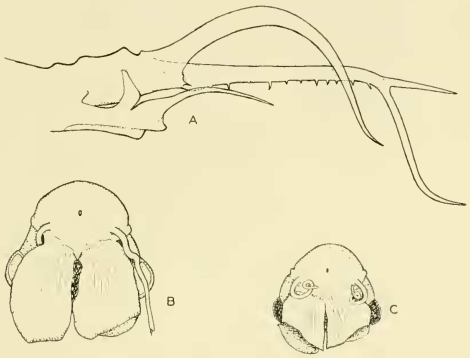

Figure 12.—*Streptocephalus dichotomus*. A, left hand of Madras spur tank ♂ from outer side (× 11.6). B, head of Tanjore ♀ from in front. C, head of Madras ♀ from in front. (B and C × 9.9).

(There are also about a dozen ♀ ♀ from Mirzapur, collected by Mrs. N. M. Johnstone, which may be of this species or of *S. simplex*, as the females are indistinguishable. This is by no means rare among the Anostraca—for example, no distinguishing marks have been reported which allow of the separation of the ♀ ♀ of any of the numerous species of *Branchipodopsis*.)

Sars' redescription of this species is so very complete that it will be unnecessary to discuss it very fully. A few points of interest have been observed, however, because of the larger collections from a more wide area that have been available to me.

The species in general is very like *S. simplex*, differing mainly in the structure of the 2nd antennae of the ♂, the middle joint of which usually bears proximally 4 fleshy processes, though the ♂ from Bangalore and one of those from the Madras Spur tank have only 3 as in

S. simplex. The finger-notch is generally more deep and open than in the forms described above, and the main branch of the finger is always bifurcated for about its last third. The bifurcation is so constructed that from the outer side the ventral branch appears to be an enlarged spine, while from the inner face, the dorsal branch gives that appearance. Both branches may be smooth, or either or both may bear minute spinules. Baird had only the ♂ of this species, and Sars says "Antennae in female simple, blade-like, bluntly rounded at the tip; . . ." All 16 ♀ ♀ examined by me had the 2nd antennae folded and wrinkled to a greater or less degree, even the very immature specimens from Mirzapur showing it plainly

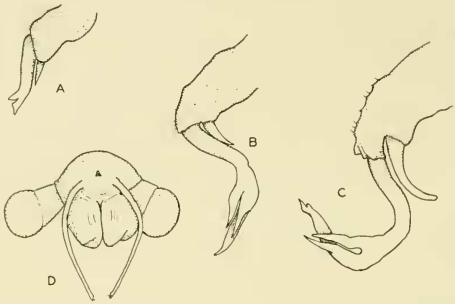

FIGURE 13.—*Streptocephalus*. A, left 2nd antenna of young ♂ *S. simplex* from Nundy, seen from outer side. B, same, somewhat older specimen. C, left 2nd antenna of young ♂ *S. dichotomus* from Mirzapur, of about the same age as B. D, head of a very young ♀ *S. simplex* from Nundy, seen from in front. The Nundy specimens are too young to determine the subspecies.

This agrees with the statement of Alcock (1897) who described the species under the name of *Branchipus* (*Streptocephalus*) *bengalensis*, though his figure is almost the precise antithesis of his description. The 1st antennae of the ♀ ♀, and to a lesser extent of the ♂ ♂, are frequently coiled, and often hidden under the 2nd antennae. In neither sex do the 1st antennae appear segmented.

The bifurcation of the main branch of the 2nd antennae of the ♂ appears very early. A young stage is shown in Figure 13, c. (The *S. simplex* from Nundy, Figure 13, a, b, d, are not old enough to place certainly as to subspecies, except to say that they are not *echinus*. They are in all probability *S. s. simplex*.)

All the forms of *Streptocephalus* here in discussion are quite closely related to each other, but not to any other forms. If we regard the flat, unfolded 2nd antenna of the ♀ as primitive (it appears nearly universally throughout the genus), it is clear that the oldest member of the group is that closest to the African center of distribution of the genus. No *Streptocephali* are known to occur along the present land route between Arabia and India. This may be because of inadequate collecting, or the distribution may have taken place before the present arrangement of the land masses.

Key to the Species and Subspecies of the Genus Streptocephalus of the Indian Empire

1. ♂ with a complex frontal process, and strong spines on some of the abdominal segments.....*S. spinifer*[2]

2. ♂ with abdominal segments unarmed

A. Main branch of finger of 2nd antenna of ♂ bifurcate distally.....*S. dichotomus*

B. Main branch of finger of 2nd antenna of ♂ not branched

i. Thumb beyond thumb-notch at least as long as main branch of ♂ 2nd antenna.....*S. simplex longimanus*

ii. Thumb not over 4/5 as long as main branch of finger

a. Basal joints of 2nd antennae of ♂ more or less fused dorsally, obscuring frontal process.....*S. simplex arabicus*

b. Basal joints of 2nd antennae of ♂ not fused dorsally, frontal process visible from above

b_1. Concave edge of sickle-shaped branch of finger smooth or nearly so.....*S. simplex simplex*

b_2. Concave edge of sickle-shaped branch spiniferous.....*S. simplex echinus*

Ecology and Zoogeography of the Indian Anostraca

The Anostraca as a whole are slow swimmers with no sort of protective devices or behavior. Introduced into an aquarium, they became immediate prey to any sort of fish, and when they are in company with copepods or even cladocera, the Anostraca are always the first to be eaten, usually being exterminated before any appreciable inroads have been made on the other forms. I once discovered the skeleton of a single, small fish in the dried bed of a temporary pond of considerable size which was known to have contained *Branchinecta occidentalis* the previous wet season. Outside of this one, rather circumstantial observation, I have never seen reported a single case of Anostraca and fish being found in the same waters.

Possibly in connection with this vulnerability, various devices have arisen which have the effect of preventing the co-occurrence of these phyllopods and fish. *Artemia* will only live in waters too saline for most fish to inhabit. The other forms may, in the main, be divided into 2 classes: Those with eggs that require drying to hatch, and those with eggs requiring freezing. In many temperate regions the eggs may undergo both processes without detriment. It is not known whether any species require both, or whether in any form drying can substitute for freezing or vice versa.

As a result it may be said that the Anostraca are ordinarily found in small, shallow bodies of water, usually of a temporary nature, and that there is usually only 1 generation a year.

Of the Indian anostracans it may be surmised that both *Branchinecta orientalis* (the specimens taken from Togarma Tso, 5,217 m., are from the greatest altitude I have been able

[2] Found only in Ceylon and not discussed in this paper. Cf. Gurney. Spolia Ceylanica 4 (14-15): 127, 1906.

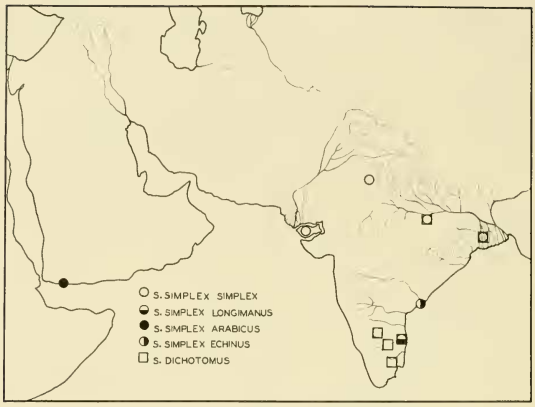

FIGURE 14.—Map of *Streptocephalus* localities.

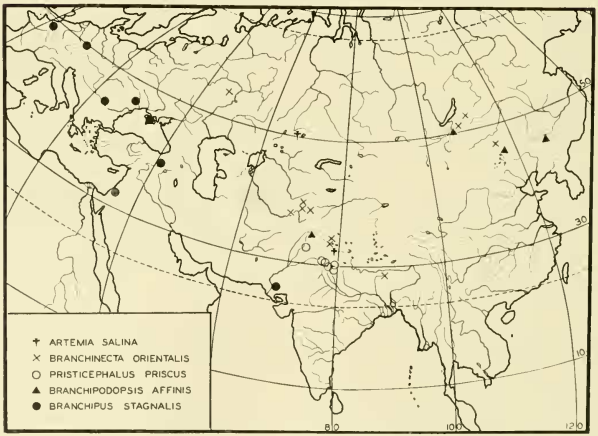

FIGURE 15.—Map of the distribution of the Indian Anostraca except *Streptocephalus*.

to find reported for any Phyllopod) and *Branchipodopsis affinis* have eggs requiring freezing (though this may not be so), and certainly that the eggs of the *Branchipus* and of the *Streptocephali* require drying. The finding of *Pristicephalus* in the Sargodhar District seems to show that these eggs require drying. It is perfectly possible, of course, that this (and other forms) may have the eggs made ready for hatching by either method indiscriminately.

Since the eggs will (in most species, perhaps all) withstand long periods of drought, and since they are small and light, it might be expected that they would easily and often be transported by the feet of water birds, by the wind, or by other agencies. As a matter of fact, however, the ranges of many species are surprisingly circumscribed, even though ponds and pools offering apparently ideal conditions are to be found a short distance away. Other, perhaps related, species may be very widely distributed, with, so far as has been determined, no more efficient method of dispersal.

This curious sort of distribution may perhaps best be explained by the presence or absence of various necessary, or destructive, factors in the various environments, the different species differing, of course, in their requirements or sensitivity. Unhappily, very little is known of the particular ecological factors involved, with the exception of *Artemia* from certain regions, and since the environment of brine-pools and salterns is so special, little light is thrown upon the situation in other genera. Though there is little experimental evidence, it appears probable that temperature is a very important factor, not only in the freezing of eggs, but there is reason to suppose that there are both maximum and minimum, sharply limiting temperatures for many, if not all, species. Thus Heath (1924) has shown that hatching and the early stages of development in *Branchinecta occidentalis* may take place at lower temperatures, but that sexual maturity is only attained after the water has risen to a temperature of approximately 22°C., despite abundant food and other suitable conditions.

The Himalayan Mountain system makes a more or less sharp temperature barrier between North and South, and the higher part of the plateau, even south of the crest is, undoubtedly, for such species as *Branchipodopsis affinis* essentially similar to Manchuria and Mongolia. Whether this form is to be found in many places between the present known sites, or whether it reached the Himalayan plateau at a period colder than the present, it is impossible to say. The very occurrence of this species in the cold parts of Asia is at present not easy to explain, since all the other 11 known species of the genus are found only in the warm and dry parts of South Africa. The arrival of *Branchinecta orientalis* was probably from the North and West, where it now occurs, and in which direction other members of the genus are to be found. *Pristicephalus priscus* may be surmised to have come from the North and West also, since its closest relatives are to be found in that direction. Because of its differentiation and restricted range it would appear to have arrived at an earlier date than the other northern forms, however. *Branchipus stagnalis*, like *Streptocephalus*, probably arrived from the West, though it is odd that it has been met with only once, and it appears barely possible that it may have been a chance importation through the agency of modern man.

The localities in which the various forms of *Streptocephalus* are found are shown on the map, Figure 14. The other species are shown in Figure 15.

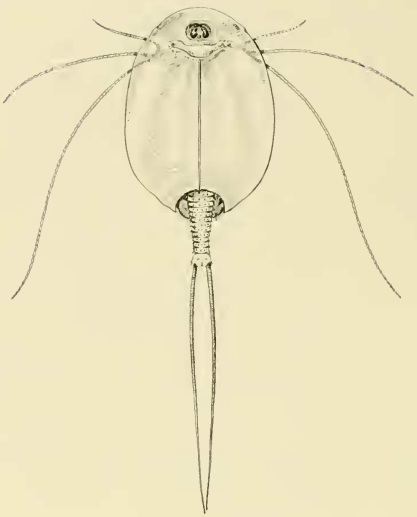

FIGURE 16.—*Apus cancriformis* ♀ from Nuriwala.

Suborder 2 NOTOSTRACA

1867 *Notostraca* Sars. Crust. d'eau douce Norv. : 5

Genus *Apus* Schaeffer

1756 *Apus* Schaeffer. Der krebsartige Kiefenfuss, etc. : 131

1803 *Triops* Schrank. Fauna Boica 3 : 251

The correct name for this genus is by no means settled, and though *Triops* is in general use at the present in continental Europe, I believe that only *Apus* has been used by the various authors who have treated of the genus in the Indian region. The arguments for this usage are so well presented by Stebbing (1910) and Gurney (1923,1924), particularly the former, that I feel constrained to follow their usage in this paper.

Apus cancriformis Schaeffer

1756 *Apus cancriformis* Schaeffer. Der krebsartige Kiefenfuss, etc.

Locality: PUNJAB: Sargodhar District, 3 mi. South of Nuriwala. 2♀♀. 6-III-32.

Reported from: Europe, Northern Africa. Kashmir (sec. Barnard).

Carapace oval, slightly longer than broad. Nuchal organ (between the posterior margins of the compound eyes) oval as seen from above, conical as seen from the side. Number of postpedigerous segments in ♂ 6-8, in ♀ 5-8. Fourth endite of 1st leg longer than carapace. Rami of caudal furca as long as all the rest of the animal, or longer.

The 2 ♀♀ of the collection have 8 postpedigerous segments each—an unusually large number. The other characters agree so well, however, that there is no doubt of the correctness of the identification. (See Figure 16, drawn by Miss L. Krause.) In nothern Europe this species is generally parthenogenetic. Whether this is true in this Indian locality the collection is too small to show.

On various bases this species has been divided into a number of subspecies, but as Barnard (1929) has so clearly shown in his study of the South African forms, the diagnostic characters chosen have no taxonomic value and simply result from individual variation (Cf. also Gurney (1923)). India may or may not harbor a valid subspecies, but this can only be determined by a study of some hundreds of specimens.

Suborder 3 CONCHOSTRACA

1867 *Conchostraca* Sars. Crust. d'eau douce Norv. : 5

Family LIMNADIIDAE Sars

1896 *Limnadiidae* (part.) Sars, Fauna Norv. 1:84

Shell thin, pellucid, ovate with few and inconspicuous growth lines. Head of adult with frontal appendage. 18-32 pairs of legs, 1st and 2nd pairs in ♂ prehensile. 9th, 10th and sometimes 11th pairs of legs in ♀ ovigerous. Caudal furca claw-like.

Three not very well defined genera.

Genus *Eulimnadia* Packard-Daday

1874 *Eulimnadia* Packard. Rep. Peab. Acad. Sci. Salem. 6:55

1925 *Eulimnadia* Daday. Ann. Sci. Nat. (ser. 10) 8:145; (9:1-3 (1926))

Hinge line of shell not serrate. 18 or 20 pairs of legs. Lower distal angle of telson (last abdominal segment) produced into an acute point.

Eulimnadia margaretae n. sp.

Locality: South Arabia: Aden, 9 ♀♀. 7-XII-32.

Types: Peabody Museum of Yale University. Paratypes: Indian Museum, British Museum, and retained.

Description of ♀ (♂ unknown). Shell transparent, oval, highest point just anterior to the middle. Hinge line evenly arcuate. Growth lines 3 in number, the outermost extremely indistinct. Rostrum in ♀ rounded, or bluntly acute (especially in younger specimens); frontal

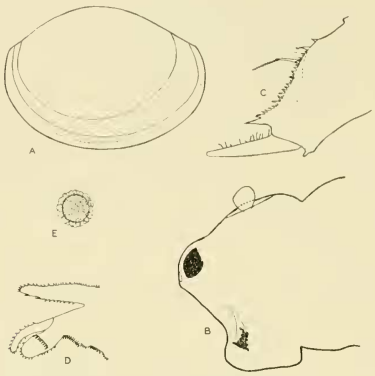

Figure 17.—**Eulimnadia margaretae.** A, shell of ♀ from left side (× 5.8). B, head of ♀ from left side (× 20.5). C, telson of ♀ from right side (× 20.5). D, distal part of left 1st leg of ♀ from behind. Bases only of the setae are shown (× 22). E, egg (× 43).

organ subglobular; posterio-ventral margin of head nearly straight, sinuous, or with a more or less sharp notch. First antennae with 6 and terminal lobes; 2nd antennae with branches of 7 and 9 segments. Twenty pairs of legs, of which pairs 10 and 11 are ovigerous. Posterior 9-13 segments bearing dorsal setae of variable number and difficult to count (setal numbers from behind forward on Type: 5?, 5?, 7?, 7, 7?, 7?, 7?, 5?, 3, 1, 1, 1, 1). Telson much worn in all specimens, with about 35 small, irregular dorsal spines, all of which are smooth; lower distal angle of telson produced into a short, rounded (possibly worn) point. Furcal claws of all specimens broken, with rounded ends; the bases of about 20 plumose setae can be made out on each claw, but most of them are broken off. Dimensions of shell: 10.4 x 7.4 mm. Ova spherical, rugose. This form does not very closely resemble any of the species described hitherto.

Family Cyzicidae Stebbing-Barnard

1910 *Cyzicidae* (part.) Stebbing. Ann. S. Afr. Mus. 6:486

1929 *Cyzicidae* Barnard. Ann. S. Afr. Mus. 29 (1) : 253

"Shell thin, pellucid (but often rendered opaque with extraneous matter), laterally compressed, ovate in outline, with numerous and distinct growth-lines and more or less distinct surface sculpturing. Head without frontal appendage, with distinct fornix on each side extending to apex of rostrum. Rostrum unarmed, or with a minute apical spinule in the young which may persist in adult ♀, but not in adult ♂. Eyes contiguous. First antennae long with numerous lobes on anterior margin bearing sensory setae. Second antenna strong. Twenty to twenty-seven pairs of legs; 1st and 2nd pairs in ♂ prehensile, 9th and 10th pairs in ♀ ovigerous. Caudal furca claw-like. Foremost tooth on upper margin of telson larger and stronger than the following ones." (Barnard.)

Genus *Eocyzicus* Daday

1913 *Eocyzicus* Daday. Math. Termt. Ert. 31 : 567, 574 (sec. Barnard)

1915 *Eocyzicus* Daday. Ann. Sci. Nat. (ser. 9) 29:190

With occipital angle rounded or rounded-quadrate in both sexes. Rostrum of ♀ acute, of ♂ with a less sharp angle (often obtuse).

Eocyzicus hutchinsoni n. sp.

Localities: Punjab: Tahsil of Kushab, Dam between Naushara and Mardwal 1 ♂ 1 ♀. 12-III-32.

Punjab: Tahsil of Kushab, 3 miles south on Nuriwala, Kushab-Naushara Road 2 ♀ ♀. 6-III-32.

Types: Peabody Museum of Yale University. Paratypes: British Museum, 1 retained.

Male: (Type only.) Shell ovate, umbone moderately prominent, dorsal margin straight, passing almost imperceptibly into hind margin; about 15 growth lines, outermost and innermost very faint; free margin and outer 2-3 growth lines with minute spines. Pits of shell sculpture moderately large but so shallow as to be obscure. Rostrum of ♂ acute (extreme end minutely truncated); posterior angle of rostrum rounded; anterior and posterior margins of rostrum nearly parallel. Supraorbital margin of head sinuous. First antennae with about 14 lobes; 2nd antennae with both rami of 12-14 joints; spines on anterior margins of joints smooth, or a few slightly ctenate. Twenty-two pairs of legs; inner margin of the "hand" of prehensile legs with strong notch in 1st pair, slightly sinuous in 2nd pair; "thumb" broad; spinous patch long and narrow in both pairs. Last 14 pedigerous segments armed dorsally (spine-formula from behind forward: 1, 1, 1, 1, 3?, 3, 3, 3, 3, 3, 3, 2, 1, 1). Telson with claws markedly asymmetrical, each preceded by 14 smooth, very unequal denticles, of which 1 near the middle of the row is about as large as the first. Furcal claw with 7 plumose setae on the dorsal, inner margin. Dimensions of shell: 10.6 x 6.9 mm.

Female: Shell as in ♂, but with umbones much less prominent; about 12 growth lines, the outermost very faint. Rostrum sharply acute. First antennae with about 18 lobes; 2nd antennae with both rami with 11-13 joints; spines on joints as in the ♂. Twenty-two pairs of legs; 1st pair with 6th endite extending as far as distal end of flabellum or beyond; palp

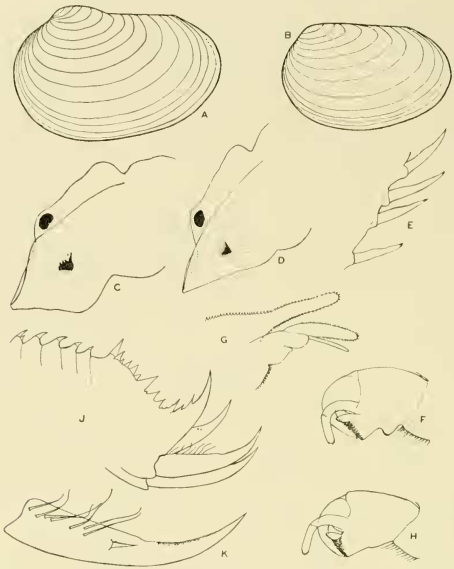

FIGURE 18.—**Eocyzicus hutchinsoni.** A, B, shells of ♂ and ♀ from left side (×5.8). C, D, heads of ♂ and ♀ from left side (×13.5). E, spines on anterior side of 1st joint of anterior ramus of 2nd antenna of ♀ (×135). F, left 1st hand of ♂ from behind (×18). G, distal part of right 1st leg of ♀ from behind. The position of some of the setae is indicated by their bases (×21). H, left 2nd hand of ♂ from behind. (×18). J, telson of ♂ from left side (×22). K, right furcal claw of ♂ from left side (×44).

of 5th endite extending nearly to end of 6th endite; 5th endite much less than half as long as 6th; 4th endite without palp; notches between endites shallow; 9th and 10th pairs of legs ovigerous. Last 15 or 16 pedigerous segments armed dorsally (formula of type, from behind forward: 3, 3, 3, 5, 5, 5, 5, 6?, 5, 5, 4?, 3, 3?, 1, 1, (1)). Telson with claws less asymmetrical than in ♂, preceded by about 26 smooth, unequal denticles, with 1 very prominent near the middle of the row. Furcal claw as in ♂. Dimensions of shell: 8.8 x 5.5 mm. Eggs rugose.

Eocyzicus deterrana n. sp.

Locality: PUNJAB: Rawalpindi District, Sohawa. About 45 ♂ ♂ ♀ ♀. 3-III-32.

Types: Peabody Museum, Yale University. Paratypes; Indian Museum; retained.

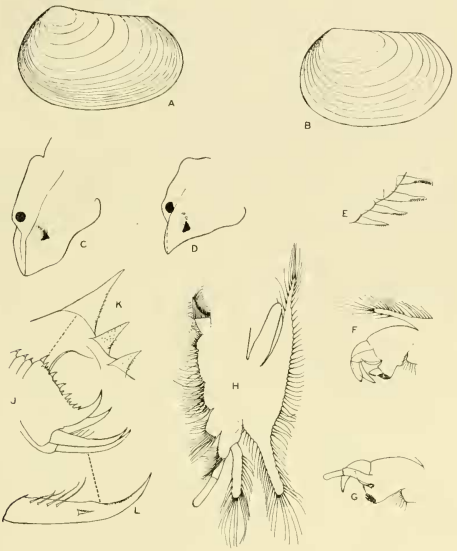

FIGURE 19.—**Eocyzicus deterrana.** A, B, shells of ♂ and ♀ from left side (×7). C, D, heads of ♂ and ♀ from left side (×13.5). E, spines on anterior side of 1st joints of anterior ramus of 2nd antenna of ♀ (×135). F, G, left 1st and 2nd feet of ♂ from behind (×18). H, left 3d leg of ♂ (×20). J, telson of ♂ from left side (×22). K, enlargement of part of J (×135). L, right furcal claw of ♂ from left side (×44).

Male: Shell ovate, umbone low; dorsal margin straight, often making a definite angle with hind margin; about 14 growth lines, the outer ones obscure and crowded; free margin and outer 3-4 growth lines with minute spines. Pits of shell sculpture small, very shallow, difficult to observe. Rostrum of ♂ acute, nearly a right angle; posterior angle of rostrum very obtuse. Supraorbital margin of head straight. First antennae with about 16 lobes; 2nd antennae with both rami of 11-12 joints; spines on anterior margin of joints smooth or ctenate. Twenty-two pairs of legs (5 specimens); inner margin of "hand" of prehensile legs

with slight notch in 1st pair; nearly straight in 2nd; "thumb" square in 1st pair, slightly broader in 2nd; in both pairs base of spinous patch of thumb only slightly longer than the spines. Last 15 (about) segments armed dorsally (spine-formula of type, from behind forward: 1, 1, 3, 3, 3, 4, 4, 5, 5, 5, 5, 4, 2?, 2, 1).

Telson with claws moderately asymmetrical, each preceded by about 12 very unequal denticles, of which 2 or 3 near the middle of the row are nearly as large as the 1st; 1st (anteriormost) denticle, and some of those following, armed with very fine spinules. Furcal claw with 4 plumose setae on the dorsal, inner margin. Dimensions of shell: 6.6 x 4.0 mm.

Female: Shell as in ♂ but with umbones even less prominent; about 11 growth lines, the outer ones indistinct and crowded and the inner ones very indistinct. Rostrum acute; supraorbital margin of head sinuous. First antennae with about 14 lobes; 2nd antennae with both rami with 11-12 joints; spines on anterior margin of these joints strongly ctenate. Twenty-two pairs of legs (4 specimens); 1st pair with 6th endite extending as far as distal end of flabellum or beyond; palp of 5th endite extending nearly to end of 6th endite; 5th endite much less than half as long as 6th; 4th endite without palp; notches between endites shallow; 9th and 10th legs ovigerous. Last 14 segments of type armed dorsally (formula, from behind forward: 1, 1, 3, 3, 3, 4, 4, 5, 5, 4?, 3, 3, 1, 1). Telson with claws scarcely at all asymmetrical, preceded by about 17 unequal, mostly armed denticles (as in the ♂) of which 2 or more in the middle of the row are about the size of the first (anteriormost). Furcal claw as in the ♂. Dimensions of shell: 6.0 x 3.8 mm. Eggs rugose.

No such careful piece of work has ever been done on the genus *Eocyzicus* as Barnard (1929) has done for *Apus*, so that the extent of variation within a natural species is not known; nor is it known which of the structural details of these Conchostraca are reliable specific criteria. When such an investigation is made, it may possibly be found that one or both of the above-described species must be reduced to synonymy with others already known, but in the present state of our knowledge of the group it is probably better to describe as new any specimens about which there is reasonable doubt.

The nearest described relative to *E. hutchinsoni* is probably the wide-ranging *E. orientalis* Daday, itself very close to *E. bouvieri* Daday, which differs most conspicuously from the new species in the shape of the rostrum of the ♂, and in the presence of a well-marked palp on endite 4 of the leg 1 of the ♀. *E. deterrana* is most similar to *E. perrieri* Daday, from Tobolsk and Buchara, U. S. S. R., but the latter has only 20 pairs of legs, and the "hands" of the ♂ ♂ of the two species differ in shape.

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